Ames Arc Jets in Support for Planetary Defense

Ernest Fretter,*
*NASA Ames Research Center, Moffett Field, CA 94035, USA

Arc Heater Background

- Routine way of testing and qualifying entry capsule thermal protection materials for all NASA missions since the mid 1950s
- Constant electric discharge between two sets of electrodes to heat a gas (nominally air), increasing total pressure and temperature (>6000 K)
- Arc-heated gas expanded through a converging-diverging nozzle and onto a test article to achieve flight-like pressures, shear stresses, and heat rates
- Facility has been used in the past for testing meteoritic material [1]
- Simulation tools used for flight predictions are used for the facility as well

Nominal Arc Jet Capabilities

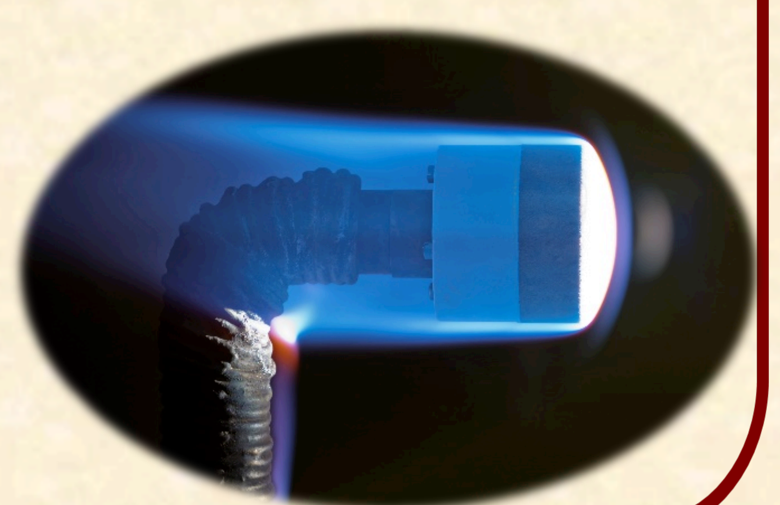
Test gas	Air, N_2, O_2, CO_2, Argon		**Test duration (min)**	≤ 60	
Nozzle exit (mm)	Conical , Ø 76, 152, 330, 533, 762 &1041	Semielliptical, 203x813	**Test article type**	Stagnation point	Wedge/Flat plate
Input power (MW)	60		**Test article size (mm)**	Ø 380	610 x 610
Bulk enthalpy (MJ/kg)	2 to 28		**Surface pressure, kPa**	1- 600	0.01-2
Flow rates (kg/s)	0.03 to 1.7		**Heating rate (W/cm²) ***	25-2000	6-400

❖ Cold wall, fully catalytic heating on a 102-mm Φ hemisphere

1. Meteor Ablation Studies

Contribute data to a thermal response model of meteoritic materials

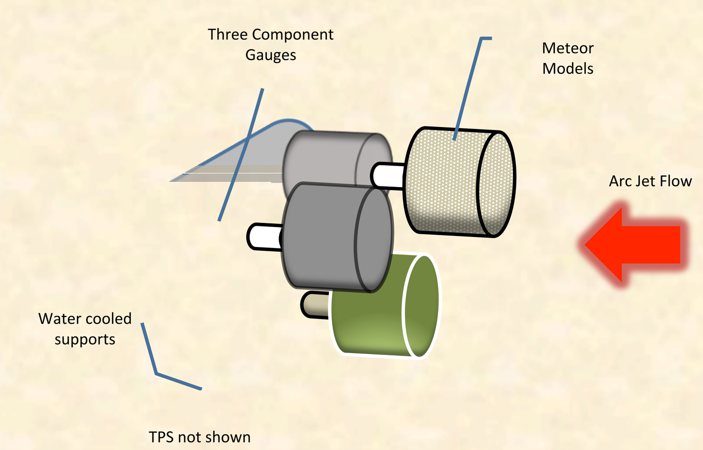
- 3-inch nozzle convective heating series
  - Convective heating promotes melting & creation of fusion crust
  - Up to 8 kW/cm² on a 1.3 cm (0.5 inch) sample at 4 bar
  - High speed video and spectrometry to observe ablation
  - Pyrometry and IR imagery of ablating surface
- Radiative heating capability being added late 2016
  - Between 100 and 150 kW available



#2. Multi-Body Breakup in Arc Jet Convective Heating Environment

Contribute data to models for interaction of multiple bodies

- Two to three bodies on special strut with temperature and force measurements of each body
- Insert multi-body model into flow and record movements, forces & test sample temperatures
- High speed video, IR imagery
- Complement data from ballistic range tests



Diagnostics

- Thermal performance @ known pressure, heat flux, enthalpy, time
  - Recession & mass loss
  - Surface temperature history, back face temperatures, cold trap option
  - High-speed video, photographic data, IR imagery
  - Post test dissection/inspection
- Spectrographic Data*
  - Focus on stagnation point and/or wake
  - Look for presence and intensity of possible species in the visible/near IR range
    - Si, SiO, Si^+, Mg, MgO, Fe, FeO, S, Na, Ca, K
  - Validate radiative and thermal models

* Spectrographic support from Megan MacDonald, PhD (Jacobs Technology)

Expected Results

- Development and validation of meteoric materials' thermal response to simulated entry conditions.
- Simulation of bow shock ablation-products mixing and resulting spectral emission – validate flow simulations and levels of mixing
- Validation of interactions that occur between free-flying bodies during fragmentation.

References

1. C. Shepard, J. Vorreiter, H. Stine, W. Winovich, "A Study of Artificial Meteors as Ablators," NASA TN D-3740, March 1967